THE ECO-HOUSE, WELLINGTON (1995)

A Critical Reassessment

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“We know that the white man does not understand our ways. He is a stranger who comes in the night and takes from the land whatever he needs. The earth is not his friend, but his enemy, and when he’s conquered it he moves on. He kidnaps the earth from his children. His appetite will devour the earth and leave behind a desert. If all the beasts were gone, we could die from a great loneliness of the spirit, for whatever happens to the beasts happens to us. All things are connected. Whatever befalls the Earth, befalls the children of the Earth."

American Indian Chief Seattle[1]

[1] James Wines, *Green architecture*. Köln, London: Taschen, 2000, p.35.

ABSTRACT

This paper examines the first Eco-house that was built by the Wellington City Council (WCC) in 1995. With this project, the WCC began to take up the challenge to reduce the wasting of energy and material resources. The building is the result of an architectural design competition which was initiated by the WCC to promote sustainable urban design and architecture. The architects Anna Kemble-Welch and Martin Hanley won the competition for the Eco-house. Their built solution is a compact, user and environmentally friendly home of about 112m² that could be built for NZD 120,000.

This paper traces the different design and construction techniques used for the Eco-house. It explores the ideas pursued by the architects in terms of energy conservation, material resources and water conservation, as well as allogen aware design that is linked to sustainable architecture. This paper deals with how these theoretical ideas were transferred into the building itself and the desired effects of each solution.

Having outlined the design and construction techniques of the Eco-house, this paper provides a critical reassessment. The critique reveals which techniques were not evolved enough to yield the desired effects in terms of ecological design. It also illustrates developments in sustainable design since 1995 and offers suggestions on what might be done differently if a similar project was carried out today.

The paper shows that the Eco-house is still a landmark example for the theory and practice of sustainable architecture in Wellington, but the focus has grown since 1995. In some aspects material choices and building methods of the Eco-house are now dated, as well as the design process that needs to be revised to reach the goals of today's problems.

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ABBREVIATIONS

ECNZ	Electricity Corporation of New Zealand
GLS	General Lighting Service
LCA	Life Cycle Assessment
PV	Photovoltaic
UNCED	United Nations Conference on Environment and Development
VOC	Volatile Organic Content
WCC	Wellington City Council

INTRODUCTION

A particular interest in the relationship between architecture and the recent global warming has inspired this research on the development of building techniques that are aimed at limiting the triggers of the climate change. The goal of this research paper is to examine opportunities in architectural design which are aimed at reducing the wasting of energy. However, it must also be asked whether or not the building techniques of the late last century are still up to date in terms of energy conservation, material resources, water conservation, allogen aware design, costing – and finally, the design process itself.

It may seem that during the last century, society has lost touch with nature in terms of green architecture. The opportunities for a reversal of this trend are given to the political expedience. A report in The Times of 18 October 1995 stated that global warming is a confirmed fact and not merely a controversial theory. [1] Also, international business and government communities are now holding a series of urgent conferences aimed at finding global remedies. Governments are starting to admit the vast extent of environmental destruction. However, as of yet, comparatively little visible action has been taken. [2]

The scope of this research paper is the first Eco-house that was built by the Wellington City Council (WCC), in 1995. The research paper outlines the design and construction techniques that were used in the Eco-house project in order to reduce the wasting of energy at all stages of the project. This paper indicates problems of materials and shows that the design process needs to be revised as well. Overall, the WCC promoted sustainable urban design and architecture with the idea of an Eco-house competition won by architects Anna Kemble-Welch and Martin Hanley. The paper examines their idea of an Eco-house that was a compact, user and environmentally friendly home of about 112 m² and could be built for NZD 120,000, in 1995.

The research paper is presented in four parts: part one describes the Eco-house competition of the WCC. Part two outlines the design and construction techniques of the building. It also elaborates on developments in sustainable design since 1995 and shows how successful or incomplete some techniques and methods were. Part three offers suggestions on what would be done differently if a similar project was pursued today and how the focus changed since 1995. The overall conclusion is presented in part four.

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[1] Brenda and Robert Vale, *The New Autonomous House* (London: Thames & Hudson, 2000), p.15.
[2] James Wines (eds.), *Green architecture* (Köln, London: Taschen, 2000), p.35.

1. THE WELLINGTON CITY COUNCIL'S ECO-HOUSE COMPETITION

The idea to organize an international competition for the design of an environmentally friendly house was first brought up in 1993 by Wellington City Councillor (WCC) Stephen Rainbow, a member of the housing and community development committee. He suggested a project which would be designed on ecologically sustainable lines and that would promote sustainable urban design solutions. In this case, Stephen Rainbow was also member of the jury. The other jury members were Marguerite Scaife (Wellington architect and New Zealand Institute of Architects Environmental Task Group Convenor), Gerald Melling (Wellington architect, Melling: Morse Architects) and Paula Comerford (Housing manager, WCC). [1]

1.1. THE ADMISSION CRITERIA OF THE ECO-House COMPETITION

The council outlined five goals to establish a framework for all entries: The design solution had to address a wide range of issues which were affecting the environment. As a second and third point, the building had to be connected to the existing urban infrastructure and the site development itself needed to appropriate to the neighbourhood. Lastly, the design had to be focused for discussion and innovation in case of environmental architecture, but a wide range of council tenants had to be able to get an easy inhabitation as well. The main sponsors were Capital Power, Electricity Corporation of New Zealand (ECNZ), Evans Bay Placemakers, Firths and the WCC. Overall, there were about 50 companies involved in the sponsoring. Half of the budget, however, still came from the WCC directly.

1.2. THE ENTRIES

The WCC received 37 entries for the Eco-house competition which followed these criteria and were eligible. The winning design came from architects Anna Kemble-Welch and Martin Hanley from Wellington who work together now under the brand name Red Design Architects. [2] Kemble-Welch and Hanley created a solution that provides comfort and healthy living conditions to the tenants. Their idea of an Eco-house is based on materials, technologies and skills available during the 1990s. It is an example of what was realistically possible to provide an ordinary house owner with during that time (Figure 1.1). [3] According to Kemble-Welch:

[1] Sean Lockie, 'Eco-House Competition', *Architecture New Zealand – March/April* (1994), pp.18-20.
[2] ECNZ (ed.), *The Eco House Magazine* (Wellington, 1995), p.17.
[3] John Storey, 'A paradigm of the possible', *Architecture New Zealand – 09/10* (1995), pp.26-30.

"We had a fairly good insight into what was necessary to make the Eco-house work, for example, knowing extended families and flexible living was important to many of the local cultures. The perfect design had to be practical. The occupier may have no interest in environmental concerns. It had to be very strong, and yet incorporate energy efficient aspects." [4]

Figure 1.1
The Eco-House, viewed from Regent Street (Photographed by the author, February 2008)

[4] Pers. comm. Anna Kemble-Welch in ECNZ (ed.), *The Eco House Magazine*, p.18.

2. THE METHODS TO ACHIEVE THE AIMS

The concept of the Eco-house was difficult to design with technology and conservation techniques that were based on a pure payback idea in terms of energy cost savings. In 1993, the costs of electrical power were low, the building site itself provides a sheltered position and the climate of the Wellington region is temperate. Low maintenance, performance, durability and building costs were finally the key factors in terms of the material selection, as well as the environmental viewpoint. [1] Located at the back of the site is a granny flat. This adjoining flat could potentially to be used as an additional living area for the aged part of the family. The ground floor provides wheelchair access to all areas, including two bedrooms. [2]

2.1. SOLAR GAIN AND PASSIVE VENTILATION

Before beginning to discuss such design and construction techniques for the design of an Eco-house nowadays, it is necessary to set out the design of the project in 1995. The architects wanted to provide the maximum solar gain and a high range of sunlight into the house. They distributed the rooms carefully on the floors and used a simple combination of technologies to enhance solar gain (Figure 2.1). They introduced double glazed skylights above the sitting, living and hall areas and provide a vibrant and cheerful harmonious ambience.

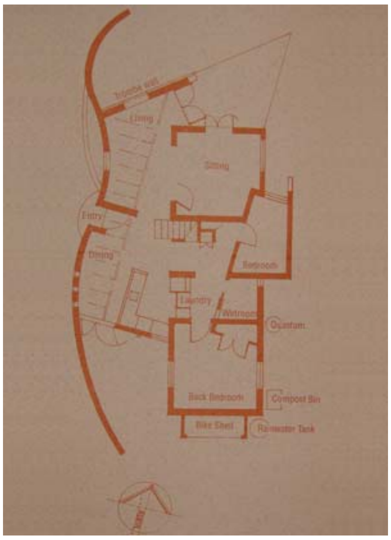

Figure 2.1
The Ground Floor Plan of the Eco-house (Courtesy of Anna Kemble-Welch and Martin Hanley, February 2008)

In order to use the stack effect, they integrated roof windows to offer passive ventilation during hot summer days. An open window at the ground level enables warm air to rise up to the highest point of the house, located near the roof windows. If the roof window is open the

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[1] John Storey, 'A paradigm of the possible', *Architecture New Zealand – 09/10* (1995), pp.26-30.
[2] John Storey, 'A paradigm of the possible', pp.26-30.

warm air can leave the building and allow fresh air to come in. During a hot day this can be done to cool down the house within a short period of time. The roof construction itself has been installed with a polyester wool mix with a thickness of approximately 130mm to provide thermal insulation.[3]

As a standard fitting of all council-owned housing, the Eco-house was outfitted with extractor fans as well. These fans were installed in the bathroom and kitchen in order to reduce moisture levels. Although they were not really needed, as the house's design already provided perfectly running passive ventilation.[4]

For the north-facing narrow street frontage the architects used a trombe wall to maximise solar gain during winter. This trombe wall was built as an interior wall and can be seen from the outside (Figure 2.2). Sunlight shines through the insulated glazing in front of it and warms up the surface of the concrete wall. At night, the stored heat gradually filters out of the thermal mass of the concrete wall. Because of the insulating glazing, the average temperature of the thermal mass can be significantly above the average outdoor temperature and heat flows into the interior.[5]

Figure 2.2
North-facing trombe heat wall, viewed from Regent Street (Photographed by the author, February 2008)

Double glazed skylights are located at the west boundary of the Eco-house to achieve passive solar heat and allow a large amount of sunlight into the house. The collected solar energy gets stored in the block walls, the reinforced concrete ceiling and the concrete floor slabs, which are finished in terracotta tiles. These components provide a high thermal mass to reduce heat loss and a polystyrene insulation under the concrete floor slabs prevents loss

[3] John Storey, 'A paradigm of the possible', pp.26-30.
[4] ECNZ (ed.), *The Eco House Magazine* (Wellington, 1995), p.5.
[5] ECNZ (ed.), *The Eco House Magazine*, p.16.

into the ground. Overall, the thermal capacity of the Eco-house minimise the temperature fluctuations and provides a suitable occupation. [6]

2.2. THE LIGHTING

The lighting of the Eco-house consists mainly of low energy fluorescent tubes. These low energy lights are situated throughout the house and generate a 75-80 % energy saving benefit compared to the power consumption of standard incandescent bulbs of the 1990s. In addition, the service life of these energy saving lights is approximately 8 times longer than that of standard general lighting service (GLS) lamps. In the case of the Eco-house, the architects used CDS PLC down lights and Philips PLC 18W compact fluorescent lamps to maximise energy efficiency. [7]

2.3. NEW ENERGY CONSERVATION SYSTEMS

On the west-side of the house is a curving wall which was built with insulated concrete blocks, also known as “Hotblocs” (Figure 2.3). These Hotblocs were used for all exterior walls. Hotblocs are self-insulating panels that eliminate the need for additional wall insulation. The Hotblocs came with an insulation biscuit material that was placed into the Hotbloc units to the outside face of the wall in order to slow heat loss to the outside. [8]

Figure 2.3
West-facing boundary wall, viewed from Regent Street (Photographed by the author, February 2008)

2.4. THE HEATING SYSTEMS

Situated in the hallway of the main house is the night store heater which is controlled by a heat boost control switch. This facility runs during the night to benefit from the lower pricing

[6] John Storey, ‘A paradigm of the possible’, pp.26-30.
[7] ECNZ (ed.), *The Eco House Magazine*, pp.9-10.
[8] ECNZ (ed.), *The Eco House Magazine*, p.8.

of off-peak electricity. It slowly releases the heat that was absorbed during the night through a pre-set level of heat.

The water heating system of the Eco-house is an environmentally friendly heat exchange system which derives most of its energy from the air and sun. The system transfers the heat into a heat pump cylinder that needs only a relatively small amount of electrical power to perform its task. If the heat exchange does not provide enough energy during the day, the heat pump can change to electrical power by using cheaper night time electricity rates. Overall, the usage of this system can cut water heating bills by up to 75 % compared to conventional water heating methods. [9]

The water heating system of the granny flat is separate from the main house. It is a combination of a solar and electric power that had only become available when the Eco-house was being planned. Instead of using water, this system uses evaporating hydrocarbon fluid as the main heat collecting medium. [10] Solar panels, known as “Thermocell Solar Panels”, are situated on the north-facing side of the roof on top of the granny flat. The gain heat goes down to a hot water cylinder that is insulated to minimise heat losses. If the solar panels cannot catch enough heat during the day to heat up the cylinder, an automatic by-pass switch changes to conventional electrical power to guarantee a supply of hot water. [11]

2.5. WATER CONSERVATION TECHNIQUES

Located at the back of the house is a water storage unit that collects rain water off the roof. This water can be used for several purposes, e.g. to water the garden area. In order to stop the wasting of water inside the house, the architects introduced different solutions. For example, a dual flush system was built into the toilet. This system with its half flush and full flush options can reduce water usage by up to 67% compared with traditional toilet flush systems. At the bathroom, lever action taps are installed and instead of a bath tube the bathroom is equipped with a shower. [12]

2.6. ASTHMA ALLOGEN AWARE DESIGN

Around 70 % of asthma patients have problems with allergen reactions caused by dust mite faeces. [13] Hard surfaces and terracotta floor tiles keep dust collection levels to an absolute minimum. Another measure to keep dust levels low as possible is visible in the back

[9] ECNZ (ed.), *The Eco House Magazine*, pp.9-10.
[10] John Storey, ‘A paradigm of the possible’, pp.26-30.
[11] ECNZ (ed.), *The Eco House Magazine*, pp.9-10.
[12] John Storey, ‘A paradigm of the possible’, pp.26-30.
[13] ECNZ (ed.), *The Eco House Magazine*, p.5.

bedroom: The room is covered with a detachable carpet, which can be lifted. This offers the possibility to take the carpet outside for beating and exposure to sunlight. [14] The ledges of the windows in every room are bevelled in order to reduce the level of dust settings. Asthma allogen aware design is evident on the outside as well. Insect and animal pollinating plants are planted in the garden area and hard paving is applied to minimise asthma allogen triggers. [15] Wellington City Council landscape architect Peter Kundycki explains:

> "In using the Eco-house as a prototype for the concept of eco-design for the Council's tenanted properties, I saw it as a challenge to design an appropriate landscape that would complement its environmentally sustainable and energy efficient features. […] The landscape design focused on aesthetic and productivity elements in the garden, choosing low allergen, compatible plants in a low maintenance tenanted home." [16]

Located in the living space is the heat pump air conditioner. This facility filters dust and pollen out of the air and keeps the air cold during summer and warm during winter months. The heat pump provides 2.5 kW of heating or cooling for every 1kW of energy that is consumed by the unit. Two low powered fans in combination with the fridge compressor provide a flow of thermostatically controlled air into the house which can be controlled by a remote controller. The architects introduced untreated Macrocarpa and Douglas Fir timber in a large range for the completion of the interior and the framing. They also used Radiata Pine timber for the construction of the skillion roof to minimise the risk of rotting under the concealed timber. [17]

2.7. THE COLOUR SCHEME

In an effort to produce a vibrant and cheerful harmonious ambience, the house is painted externally in soft yellow and earth red colours (Figure 2.4). This colour scheme is brought through the interior spaces and is combined with orange terracotta floor tiles and natural timber floors. All of the paints that were used have low Volatile Organic Content (VOC) levels that are also part of the asthma allogen aware design features of the Eco-house and well within Environmental Choice New Zealand guidelines. [18] Resene's technical director Colin Gooch explains:

[14] ECNZ (ed.), *The Eco House Magazine*, p.5.
[15] John Storey, 'A paradigm of the possible', pp.26-30.
[16] Pers. comm. Peter Kundycki in ECNZ (ed.), *The Eco House Magazine*, p.4.
[17] John Storey, 'A paradigm of the possible', pp.26-30.
[18] John Storey, 'A paradigm of the possible', pp.26-30.

"We had to look at the potential of each colour, how it would cope over time, and how best to combat natural fading. For example, the trombe wall required a dark colour to maximise solar gain." [19]

Figure 2.4

Earth-red painted *Hotbloc* wall, viewed from Regent Street *(Photographed by the author, February 2008)*

[19] Pers. comm. Colin Gooch in ECNZ (ed.), *The Eco House Magazine*, pp.20-21.

3. THE SUCCESS OF THE METHODS

Planning and construction of the Eco-house were started in the 1990s – hence, the whole project was based on the technical knowledge of these days. It was an attempt to create a building that would reach the 10-star barrier on the Branz and Hero rating system. This goal was reached and the Eco-house was in fact one of the top rating houses in New Zealand. It was a landmark and an example in energy efficiency through design. [1] Due to this, the question must be asked which of these techniques and materials were evolved enough to yield the desired effects in terms of ecological design, as well as what was not possible, e.g. in terms of legal constraints and site conditions? One of these points was the planned on-site water purification. This system was ruled out because of the low requirement, but also in terms of the existing building laws. Also composting toilets were ruled out after the WCC explained that they did not want them introduced in this publicly owned house. [2]

Other techniques, e.g. the trombe wall and the curved wall drew criticism as well as praise, but the built trombe wall adapted a remarkable change to the original design. The original trombe wall design was created with vents added to the top and bottom of the air gap between the double glazing and the thermal mass. Heated air should flow through the heating into the building. The vents itself were planed with one-way flaps which prevented convection at night and made heat flow strongly directional. These vents should be closed by the residents to the interior during summer time when it was not necessary to get heat into the house. However, in order to make it easier to the residents, the WCC wanted these vents replaced by a remote control for the night store heater to facilitate temperature control. Their thought was simply that this remote control could be more user-friendly. [3]

Furthermore, recent design options have become available and were applied into the Eco-house. One of these design options were the skylights that rendered an "outdoors-indoors" feeling, but some criticisms have been made about the lack of shading, as well as about the excessive convective cooling from the skylight strip at night. That was a problem on sunny days, but residents found a simple way to solve this problem (Figure 3.1). However, it can be said that the architects were confident with their design - the construction worked very well with outside temperature fluctuations and there was no leak of user comfort. [4]

[1] ECNZ (ed.), *The Eco House Magazine* (Wellington, 1995), p.16.
[2] John Storey, 'A paradigm of the possible', *Architecture New Zealand – 09/10* (1995), pp.26-30.
[3] Sean Lockie, 'Eco-House Competition', *Architecture New Zealand – March/April* (1994), pp.18-20.
[4] John Storey, 'A paradigm of the possible', pp.26-30.

Figure 3.1
The double glazed skylights, above living, hall and kitchen (Photographed by the author, February 2008)

Another problem was found in the construction of the curved wall, as well as in all external walls. They were built with the Hotbloc unit system. Theoretically, this system should offer warmth in winter and coolness in summer and there should be no need of additional wall insulation – however in practice, the result was incomplete. It is important to use a high quality of thermal insulation in combination with low energy heating systems if optimal results are to be achieved. Concrete blocks are also one of the favourite design materials of New Zealand builders and architects and have been so since the 1950s. The Hotbloc was a specialised medium that also provided thermal insulation. However, today it became evident that it was poorly conceived. The design was a light-weight 200 mm masonry block with a self-insulating panel, but this design was the problem. Each Hotbloc was an own thermal insulation unit that did not corporate among each other and contained thermal bridge inside the block itself. The result was a wall with a mass of diverse thermal bridges. [5]

Although, there have been compromises during the design process that were not beneficial. The heat pump and the night storage heater have not been a part of the original design. Furthermore, these technologies replaced one of the most noticeable features: a windmill that was supposed to be perched on the rooftop to run the hot water heating system. A main sponsor did not want to support this idea in order to protect its own interests. Finally, the heat pump and the night storage heater were installed as these were commercially available at the time. Also, it was argued that this system was more efficient. [6]

[5] ECNZ (ed.), *The Eco House Magazine*, p.8.
[6] John Storey, 'A paradigm of the possible', pp.26-30.

4. WHAT WOULD BE DONE DIFFERENTLY TODAY?

The New Zealand Ministry for the Environment produced a guide to the programme called Agenda 21, which was revealed by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, in 1992. [1] Today, this guide and its points are still important as they were for the Eco-house project, but the focus has grown since 1995 and more points are being looked at due to a more holistic view of the topic. Today, it is not enough to design an Eco-house that is based on a low level of energy usage and innovation in case of environmental architecture. It is necessary and possible now to take the environmental impacts of the material and building method into account.

The key heading is “Life Cycle Assessment” (LCA). The use of conventional energy resources is a major problem in terms of environmental damages. A number of alternatives can be found in the design of the Eco-house, like passive and active solar hot water systems, the use of sustainable building materials and photovoltaic solar panels, which reduce the environmental damage. The point is to find out, which one is the right choice for which project. LCA is the possibility to assess the potential environmental impact of a specific material or each building method. Studying environmental impacts through the use of LCA is the option to identify the major points to energy consumption and negative environmental impacts. LCA is focused on the potential contributions to regional and global impact categories and it presents the results as global impacts and over time. [2] As an example, major environmental improvements can be realised by the introduction of photovoltaic (PV) technologies, but a lower environmental impact does not automatically imply, when the life cycle of photovoltaic module is taken into account. This problem is the object of change in the reduction of environmental impacts. [3]

Overall, to design an Eco-house is a complex process of managing a range of related factors: site, orientation, budget, materials, etc. [4] A new Eco-house project needs to include the current technical knowledge of materials and construction methods. That means to revise the design process and to check which materials need to be replaced by materials that are more efficient and provide a lower environmental impact. As shown in chapter 3 and as an example, the thermal wall insulation was poorly realised in terms of thermal bridging, or cold bridging. Thermal insulation is a key factor and the Hotbloc system need to be replaced.

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[1] Brenda and Robert Vale, *The New Autonomous House* (London: Thames & Hudson, 2000), p.12.
[2] Arjen Meijer, *Improvement of the life cycle assessment methodology for dwellings* (Delft, England: U Pr, NE, 2006), pp.4-5.
[3] Arjen Meijer, *Improvement of the life cycle assessment methodology for dwellings*, pp.81-82.
[4] Brenda and Robert Vale, *The New Autonomous House*, p.67.

Changes in the choice of materials and the design process make it possible to save energy and to eliminate the wasting of resources in a higher level, than in 1995. The criteria of 1995 and LCA are the focus on what is relevance to design a new Eco-house today.

5. CONCLUSION

The scope of the Eco-house competition by the WCC was to design an environmentally friendly home realised and financed by a unique partnership: ECNZ, Capital Power, Firths, Placemakers and the WCC. Chapter one and two have explained the Eco-house competition with its goals and outlined the design and construction techniques. Given the technology progress since 1995, some design and construction methods as well as material choices could have been done differently nowadays. As outlined in chapter three, the architects had to deal with a number of operational problems and compromises.

As shown in chapter four, new building and design methods can offer new possibilities. Life cycle assessment (LCA) is only one of many, but it is one of the most important developments. The Eco-house was not perfect and did not give answer to all problems in terms of green architecture. However, it was necessary to realise the Eco-house as an example. The project was less concerned with innovation and more with the environmentally conscious use of available technologies and materials which could be transferred into existing homes. The important point was that the project helped to place the attention of the public on energy efficiency and environmental sustainability, as well as supporting the interest of architects and builders around the country.

Overall, it has shown that the combination of existing and newly-created techniques, forms and materials reduced the level of wasted energy considerably. The results have proved that this concept cut the average cost of heating and hot water. It was also a significant step in the development of sustainability in Wellington's architecture. The Eco-house has provided the basis for projects and developments which followed and confirmed the need of similar high quality examples for timber framed houses, as well as for the upgrade of existing houses in New Zealand.

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